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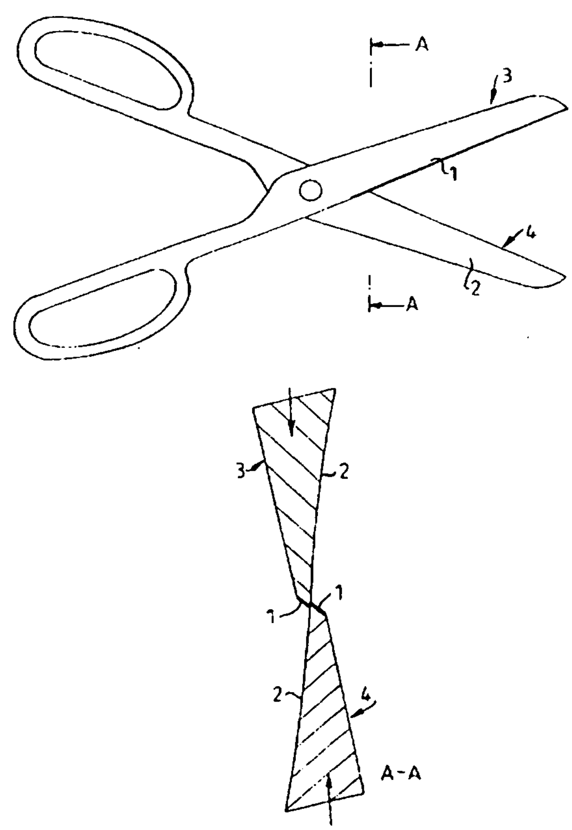
(54) Title: SELF-SHARPENING CUTTING DEVICE

(57) Abstract

A cutting device with at least one cutting part each comprising a first (1) and a second (2) face meeting at an edge, wherein on at least one of the cutting parts at least a part of the first face (1) immediately adjacent to the edge is harder than the second face (2). A method for manufacturing the cutting device of the invention from at least one prefabricated cutting part of a certain hardness each comprising a first (1) and a second (2) face meeting at an edge, whereby on at least one of the cutting parts at least a part of the first face (1) immediately adjacent to the edge is provided with a layer substantially harder than the material of the prefabricated cutting part.



Self-sharpening cutting device

Technical Field

The present invention relates to a cutting device with at least one cutting part, each part comprising a first and a second face meeting at an edge, and a method for manufacturing a cutting device from at least one prefabricated cutting part of a certain hardness each comprising a first and a second face meeting at an edge.

Prior Art

With a conventional cutting device, such as a pair of scissors, the sharpened edge where the planar inner face and the outer face meet on each cutting part, is worn during a cutting procedure due to the physical contact between the cutting material and the cutting edges. This contact of wear will result in a rounded edge configuration, i.e. one from the beginning sharpened pair of scissors will eventually get blunted. The harder the cutting material is, the quicker the cutting edges of a cutting device will be worn out. Hair is one example of a fairly hard cutting material and consequently a pair of scissors used for hair cutting will be blunted fairly quickly compared to other cutting applications. When cutting paper and textile materials, which also are examples of severe wear situations, the wear mechanisms may consist of both mechanical and chemical wear. The degree of wear will then also depend on the chemical composition of the cutting material, i.e. in the cases mentioned above on the paper or textile quality.

The European patent application EP 0 247 217 refers to a self-sharpening tool which includes a coating. In this tool the sharpening is said to take place by at least one of the two cutting parts of the tool being coated with a layer of an abrasive or honing material on its planar inner surface. The sharpening is meant to occur by the contact between the cutting edge and the abrasive layer. However this concept does, according to technical expertise, not work well.

Summary of the Invention

The purpose of the present invention is to provide a cutting device with unique self-sharpening characteristics, and a simple method for manufacturing said self-sharpening device, involving coating or hardening techniques in the last step of a manufacturing procedure.

The present inventor has found that this purpose surprisingly is achieved by a cutting device with at least one cutting part each part comprising a first and a second face meeting at an edge, wherein on at least one of the cutting parts at least a part of the first face immediately adjacent to the edge is harder than the second face.

The cutting device may comprise a first and a second cutting part, the second face of the first cutting part facing the second face of the second cutting part.

A first embodiment of the invention is a pair of scissors.

Cutting is for the purpose of this description and claims meant to include all forms of dividing by using shear force. Examples of such tools are scissors, cutting devices for paper, cloths, plastic material and any other material to be divided using shear force. The cutting device can also have the form of a permanently mounted bench cutter or a major cutting machine for industrial use equipped with cutting parts that describe linear motions up and down. The linear motion could also be combined with a rotating or pivoted motion.

Not wishing to bind the invention to any theory the following is thought to be the process of wear during a cutting procedure with a cutting device according to the invention:

When the material to be cut comes into contact with the cutting edges of two cutting parts, the second face of each cutting part will be worn in an essentially higher degree than the first face of the cutting parts. This is due to the differences in the hardness values

between the bulk material and the coated or hardness treated faces. Whereas the second face, which is relatively soft, undergoes severe wear during a cutting procedure, the first face which contains a hard coating, or is hardness treated, is protected against this severe wear. The result of this highly unsymmetrical situation is a self-sharpening effect on the cutting edge during a cutting performance.

As the crossed pivoted cutting parts of a cutting device such as a pair of scissors slide along each other, a self-sharpening effect is achieved during the shearing action of a cutting movement due to the non symmetric wear behaviour between the second softer and the first much harder material.

Another embodiment of the present invention is a cutting device comprising two circular discs with substantially parallel and spaced apart axes and peripherical edges, the discs slightly overlapping to allow one of the discs to be driven by the other disc.

Yet another embodiment of the invention is a cutting device comprising a first cutting part consisting of a punch wherein the first face is the cutting end face of the punch and the second face is the cylindrical mantle surface of the punch, and a second cutting part consisting of a punch die having an inner mantle face defining a hole, wherein the first face consists of a top face on the punch die surrounding the hole and the second face is the cylindrical mantle face.

Yet another embodiment of the invention is a cutting device comprising a first cutting part consisting of a punch wherein the second face is the cutting end face of the punch and the first face is the cylindrical mantle surface of the punch, and a second cutting part consisting of a punch die having an inner mantle face defining a hole, wherein the first face consists of a top face on the punch die surrounding the hole and the second face is the cylindrical mantle face.

In the case of only one cutting part, the device according to the invention may be a knife that is surface treated on at least part of one of the faces of the edge. This provides a self-

sharpening effect as the cutting part is asymmetrically worn, e. g. when the knife is used as a scalpel. The knife may also be circular and meant to rotate.

A prerequisite condition for the self-sharpening effect to occur is that the thickness of the hard layer does not exceed a thickness in the order of ten micrometers. If the coating is too thick, it will destroy the sharpness of the cutting edge. Another difficulty with thick coating layers is the tendency towards mechanical tensions in the coating layer, which in the worst case may cause the layer to crack. Yet another difficulty associated with the application of thick coating layers is the tendency towards formation of overhang on the cutting edge.

The thickness of the coating layer is preferably in the range of 0.01-20 μm, more preferably 0.1-3 μm and most preferably 0.5-1.5 μm.

The hardness of the harder face is preferably 1.5-30 times, more preferably 2-20 times and most preferably 3-10 times as hard as the second face expressed as Vickers hardness. The hardness of the second face is preferably 200-1500 Vickers, more preferably 400-1000 Vickers and most preferably 700-900 Vickers. The hardness of the harder face is is preferably 1500-6000 Vickers, more preferably 2000-5500 Vickers and most preferably 4000-5000 Vickers.

The required hardness of the hardening treated face depends on the materials intended to be cut, their hardness, abrasiveness etc. A quite soft not hardening treated face of a pair of scissors has a hardness between about 300 and 400 Vickers. Such a soft material cannot be used for high quality scissors; for this purpose materials with hardness values of around 600-800 Vickers are used. When the not hardening treated face has a hardness of about 800 Vickers the hardening treated face should be about 1,5-8 times as hard. With a softer not hardening treated face, the hardening treated face may be 10 or 20 times as hard as the not hardening treated face. If a coating is 30 times as hard as the not hardening treated face, there is a risk of cracking of the coating layer. A too hard bulk material has the disadvantage of being too fragile.

The invention also concerns a method of manufacturing a cutting device from at least one prefabricated cutting part of a certain hardness each comprising a first and a second face meeting at an edge, characterized in that on at least one of the cutting parts at least a part of the first face immediately adjacent to the edge is provided with a layer substantially harder than the material of the prefabricated cutting part, e. g. using a Physical Vapour Deposition coating procedure, such as a Magnetron Sputtering technique, e. g. providing a diamond like carbon or titanium nitride layer.

In this method of manufacturing a cutting device the second face can be shielded or covered by any means during the coating procedure, so that it is protected and will not be made harder. After completion of the coating the shield or cover is removed. It is also possible to coat or harden both faces of one or more of the edges, or the complete cutting device. Thereafter at least part of at least one of the faces of the edge or edges is made soft by e. g. removing the harder surface layer. The softening after the hardening treatment can be achieved by a mechanical sharpening procedure.

Examples of materials in the coating layer are e. g. nitrides, such as titanium nitride (TiN), chromium nitride, hafnium nitride, niobium nitride, boron nitride, carbides, such as titanium carbide (TiC), titanium nitrocarbide (TiNC), boron carbide, silicon carbide, diamond or diamond like carbon (DLC), chromium and/or cobalt, or combinations of such materials. An example of a combination of layers is a multi layer application, using diamond in the top layer. An advantage using titanium is the comparatively low price. Titanium nitride gives the coated surface a golden colour, whereas TiC and DLC are greyish or black. The latter material is the hardest material, displaying the best performance of the materials tested.

Although, it is only necessary to coat or hardening treat the first faces of the edge or edges to obtain the self-sharpening effect, the whole cutting device, except for the second faces of the edge or edges, can be coated or hardening treated with the same desired self-sharpening effect. Application of the coating layer can be performed to increase corrosion

resistance or to provide the tool with a biocompatible non-allergenic as well as appealing surface finish.

The coating can for example be applied by the following methods:
Physical Vapour Deposition (PVD) methods, such as Sputtering methods, Ion Plating, Laser Depletion Deposition, Hollow Cathode Arcing or Ion Beam Assisted Deposition (IBAD);
Chemical Vapour Deposition (CVD) methods, such as Thermal-induced CVD or Plasma-activated CVD;
Thermal Spraying methods, such as Plasma Arc Spraying or Plasma Vacuum Spraying.
Other methods that may be used to create a hard surface include Electrochemical Deposition, Sintering, Spraying, welding of a harder material unto the bulk material and surface hardening using laser, or any other similar technique.

The surface hardness effect can also be performed by ion implantation or ion bombardment techniques. In this case the surface is hardened down to a depth of a few hundred nanometers.

The self-sharpening phenomenon of a pair of scissors has been observed to be most effective when the PVD coating process is applied. Especially in the case of the ”Magnetron Sputtering” technique excellent results have been obtained with well defined and high quality coatings on the top inclined face of the investigated cutting device.

Brief Description of the Drawings

The invention is described below in more detail with reference to a number of exemplifying embodiments and to the accompanying drawings, in which:

Figure 1A shows a side view of a pair of scissors.

Figure 1B shows an enlarged sectional view taken along the line A-A of Figure 1.

Figure 2 shows a side view of a cutting device comprising circular discs.

Figure 3 shows a partially sectioned view of a punch.

Detailed Description of the Drawings

Figure 1A shows a side view of a pair of scissors comprising a first cutting part 3 having a coated or hardening treated first face 1, and a second cutting part 4 having an uncoated or not hardening treated second face 2.

Figure 1B shows an enlarged sectional view taken along the line A-A of Figure 1 during the cutting operation, indicating the first face 1 and the second face 2 of the first cutting part 3 and the first face 1 and the second face 2 of the second cutting part 4.

Figure 2 shows a side view of a cutting device comprising a first cutting part consisting of an upper circular disc 3 having a first face 1 and a a second face 2. The device also comprises a second cutting part consisting of a lower circular disc 4 having a first face 1 and a second face 2. The upper disc is driven by the lower disc, which is driven by a motor (not shown). This kind of circular cutting device is used for instance in paper and textile industry. The material to be cut passes perpendicularly into the plane of the side view and is cut as it passes where the discs overlap.

Figure 3 shows a partially sectioned view of a cutting device comprising a punch 3 having a first face 1 and a second face 2, and a punch die 4 having a first face 1 and second face 2.

The invention will now be descibed in further detail with reference to the following working examples, which are not intended to limit the invention.

Example 1

A TiN coating using the unbalanced magnetron sputtering PVD-technique was performed on high quality scissors for hair cutting as described below.

The scissors for hair cutting were first demounted so that each blade was separated from the other. The blades were cleaned to remove all sorts of grease or other loose surface impurities. This was performed using a fine paper tissue and then chemical solvents. First the blades were put in an ethanol bath for about five minutes. Then they were transferred to an acetone bath and left there for about five minutes, whereafter they were taken out of the bath and flushed with benzene and then with ethanol. Thereafter the blades were dried using a hot-air fan.

The blades were mounted in a deposition chamber which was vacuum pumped down to a pressure of about 10^{-6} mbar or lower. The scissors blades were mounted so that the inner side of all blades were covered with a stainless steel material which shielded the samples in order to prevent that any deposition could take place on that side of the blades.

The blades were sputter cleaned (discharge cleaned) in the vacuum chamber by setting them on a negative biasing voltage of some hundred volts up to a few thousand volts during the inlet of argon gas to a pressure of some mbars. During this process, argons ions bombarded the surface of the blades and thereby heated them up to temperatures between 150 and 500 °C depending on the discharge time.

At a temperature in this range the blades were coated using an unbalanced magnetron sputtering device, - also mounted in the deposition chamber. The sputtering target was titanium and the inlet gas consisted of argon and nitrogen. During the deposition, the blades were rotated by a specially constructed vacuum rotational device in order to obtain uniform sputtering depositions. The blades were held at a negative biasing voltage of 30-300 V during the deposition. Thus the blades were bombarded with "low" energy ions during deposition. The current of this ion beam was as high as possible for the best results concerning film adhesion and quality.

The deposition procedures was continued so that a thin film of TiN, with the thickness varying between 0.2 and 20 microns, was formed on top of the scissors blades, except for the inner sides of the blades which were kept free from any deposition.

When the deposition was finished, the scissors blades were allowed to cool down to at least below 100°C before they were taken out and assembled with screws.

Example 2

Scissors were treated as in Example 1, with the exception that methane was included in the inlet gas used in the sputtering process. This method gave a deposition of DLC as the target was poisoned by increasing the methane gas pressure to a maximum value. Thereby the titanium target was covered with a carbon layer which led to only carbon being sputtered from the target area and then deposited on the scissors.

Example 3

A series of high quality scissors were coated, by the use of the techniques described in Examples 1 and 2, with TiN and DLC films with thicknesses of around 3 micron. The hardness values of the films, measured by indentation techniques, were found to be about 2500 Vickers for the TiN films and exceeded 4500-6000 Vickers for the DLC films. The hardness value of the not hardness treated face of the scissors was around 820 Vickers

Example 4

The scissors from Examples 1 and 2 were studied as regards their sharpness characteristics by performing long time cutting tests in the following way.

One pair of scissors at a time was mounted on a specially constructed device to perform a continuous cutting movement with the blades moving back and forth. Two cutting motions were carried out per second.

During the above mentioned motion of the scissors blades, a paper strip was rolled perpendicularly across the scissors blades from one paper roll to another in a step wise manner, with cuts being made near the edge of the paper strip as the strip was at a stand still. The paper used was taken from roles normally used in strip chart recorders.

The automatic cutting procedure mentioned above was performed with uncoated, TiN coated and DLC coated scissors. The uncoated scissors were used as standard samples and comparisons with the lifetimes, i.e. the time it takes before an initially sharp pair of blades becomes unsharp, were made between this uncoated calibration sample and coated scissors blades. During the test period of one specific pair of scissors, the sharpness of the blades were controlled regularly every six hours. The study was stopped when the scissors blades had become unsharp, which was observed in an optical microscope and defined as the stage at which the edge had been rounded, i.e. the edge could be observed to be broader than about 0,5-1 micron.

Uncoated scissors blades were worn out after about six hours test running, which corresponds to about 43 000 cutting motions.

TiN and DLC coated scissors blades did not become unsharp even after more than 200 hours of testing, which corresponds to about 1 440 000 cutting motions.

Example 5

A professional hairdresser used a new pair of scissors which was coated with TiN according to Example 1 in his daily work to cut the hair of his clients (minimum 9 clients per day). An equivalent pair of uncoated scissors, which he normally used in his practice, was worn out after about 1-3 months's use. The TiN coated pair of scissors was as sharp as from the beginning, i.e. as a new pair of scissors, after 15 months of normal daily use in his practice. This particular pair of scissors is still in use and is as sharp as a new one even at the outermost tips of the scissors blades.

Claims

1. A cutting device with at least one cutting part, each part comprising a first (1) and a second (2) face meeting at an edge, characterized in that on at least one of the cutting parts at least a part of the first face (1) immediately adjacent to the edge is harder than the second face (2).

2. A cutting device according to claim 1, characterized in that it comprises a first (3) and a second (4) cutting part, the second face (2) of the first cutting part (3) facing the second face (2) of the second cutting part (4).

3. A cutting device according to claim 2, characterized in that it is a pair of scissors.

4. A cutting device according to claim 2, characterized in that the two cutting parts consist of two circular discs (3,4) with substantially parallel and spaced apart axes and peripherical edges, the discs slightly overlapping to allow one of the discs (3) to be driven by the other disc (4) .

5. A cutting device according to claim 2, characterized in that it comprises a first cutting part (3) consisting of a punch, wherein the first face (1) is the cutting end face of the punch (3) and the second face (2) is the cylindrical mantle face of the punch (3), and a second cutting part consisting of a punch die (4) having an inner mantle face defining a hole, wherein the first face (1) consists of a top face on the punch die surrounding the hole and the second face (2) is the cylindrical mantle face.

6. A cutting device according to claim 2, characterized in that it comprises a first cutting part (3) consisting of a punch, wherein the second face (2) is the cutting end face of the punch (3) and the first face (1) is the cylindrical mantle face of the punch (3), and a second cutting part consisting of a punch die (4) having an inner mantle face defining a hole, wherein the first face (1) consists of a top face on the punch die surrounding the hole and the second face (2) is the cylindrical mantle face.

7. A cutting device according to any of the above claims, characterized in that the harder first face (1) comprises a layer with a thickness of at least 0.01 μm, preferably above 0.1 μm and most preferably above 0.5 μm.

8. A cutting device according to any of the above claims, characterized in that the harder first face (1) comprises a layer with a thickness of at most 20 μm, preferably under 3 μm and most preferably under 1.5 μm.

9. A cutting device according to any of the above claims, characterized in that the harder first face (1) is at least 1.5 times, preferably 2 times and most preferably 3 times as hard as the second face (2), expressed as Vickers hardness.

10. A cutting device according to any of the above claims, characterized in that the harder first face (1) is at most 30 times, preferably 20 times and most preferably 10 times as hard as the second face (2), expressed as Vickers hardness.

11. A cutting device according to any of the above claims, characterized in that the hardness of the second face (2) is at least about 200 Vickers, preferably at least 400 Vickers and most preferably 700 Vickers.

12. A cutting device according to any of the above claims, characterized in that the hardness of the second face (2) is at most about 1500 Vickers, preferably at most 1000 Vickers and most preferably at most 900 Vickers.

13. A cutting device according to any of the above claims, characterized in that the hardness of the harder first face (1) is at least about 1500 Vickers, preferably at least 2000 Vickers and most preferably at least 4000 Vickers.

14. A cutting device according to any of the above claims, characterized in that the hardness of the harder first face (1) is at most about 6000 Vickers, preferably at least 5500 Vickers and most preferably 5000.

15. A cutting device according to any of the above claims, characterized in that at least part of the first face (1) of both the cutting parts (3,4) are harder than their second faces (2).

16. A method for manufacturing a cutting device from at least one prefabricated cutting part of a certain hardness each comprising a first (1) and a second (2) face meeting at an edge, characterized in that on at least one of the cutting parts at least a part of the first face (1) immediately adjacent to the edge is provided with a layer substantially harder than the material of the prefabricated cutting part, e. g. using a PVD coating procedure, such as a Magnetron Sputtering technique,
e. g. providing a DLC or TiN layer.

17. A method for manufacturing a cutting device according to claim 16, characterized in that the second face (2) is shielded or covered by any means during a coating procedure, so that it is protected and will not be made harder, whereafter the shield or cover is removed.

18. A method for manufacturing a cutting device according to claim 16, characterized in that at least part of at least one of the second faces (2) is made soft after a hardening treatment or that an applied harder surface layer is removed from at least part of at least one of the second faces (2) adjacent to the edge.

19. A method for manufacturing a cutting device according to claim 18, characterized in that at least part of one of the second faces (2) is made soft after the hardening treatment by a mechanical sharpening procedure.

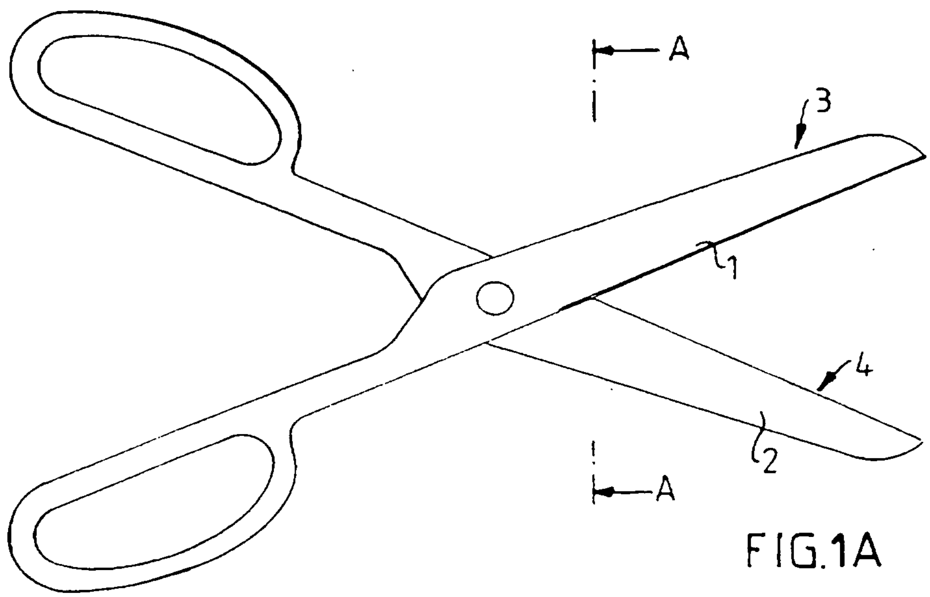


FIG.1A

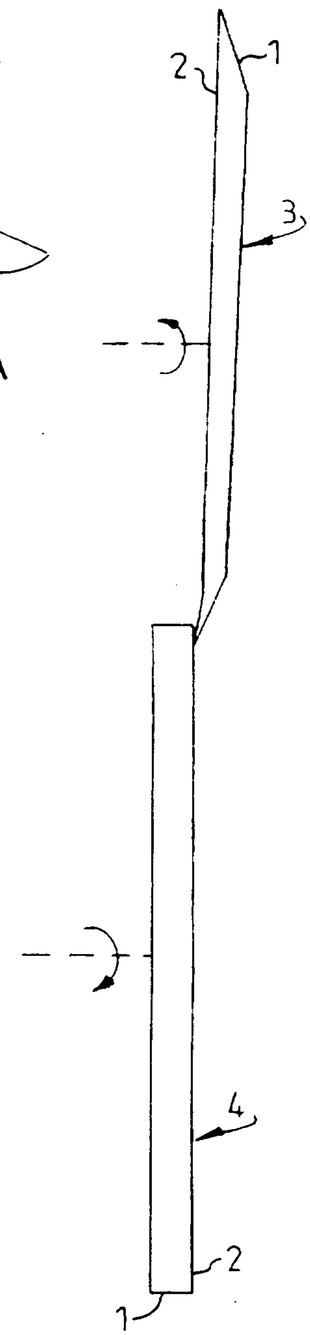


FIG. 2

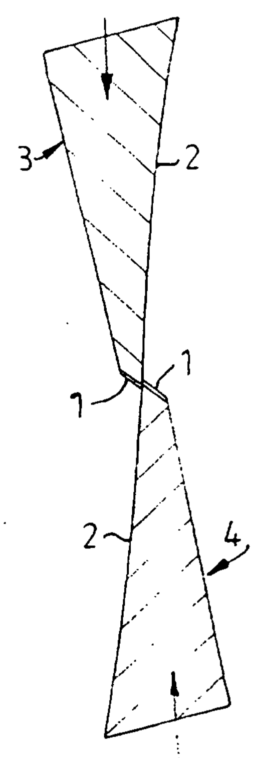


FIG.1B

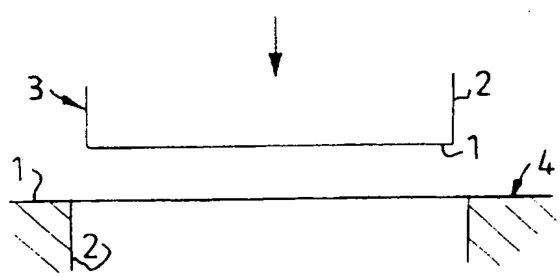


FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00685

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B26B 13/06, B26D 7/12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B26B, B26D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y		16
A	abstract	2-6,9-15, 17-19
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Y	EP 0247217 A1 (LEVINE, SOL), 2 December 1987 (02.12.87), abstract	16
A		1-15,17-19
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A	DE 3604897 A1 (ARS EDGE CO LTD), 2 October 1986 (02.10.86)	1-19
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00685

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

International application No.
06/08/97 PCT/SE 97/00685

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